INDOOR AIR QUALITY ASSESSMENT

East Brookfield Elementary School
410 East Main Street
East Brookfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
December 2004

Background/Introduction

At the request of the East Brookfield Board of Health, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the East Brookfield Elementary School (EBES), 410 East Main Street, East Brookfield, Massachusetts. On November 2, 2004, Cory Holmes, Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of the EBES. Concerns about indoor air quality related to carbon monoxide exposure from the boiler plant and potential mold growth resulting from a sprinkler release in January of 2004 prompted the request. Mr. Holmes was accompanied by Johnny Miller and Arthur Cournoyer of the East Brookfield Fire Department (EBFD), Ruth McNeaney, Clerk, East Brookfield Board of Health and Eileen Prizio, Principal, EBES.

The EBES is a two-story red brick building on slab constructed in 2002. The building contains general classrooms, computer room, art room, library, kitchen and cafeteria, gymnasium and office space. Windows are openable throughout the building

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of porous building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520.

Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). Air tests for ultrafine particulates were taken with the TSI, P-Trak ™ Ultrafine Particle Counter Model 8525.

Results

The school houses approximately 220 students in kindergarten through fourth grade and has a staff of approximately 40. Tests were taken during normal operations. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange. Fresh air in classrooms is mechanically supplied by a unit ventilator (univent) system (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents were found activated in all but one classroom surveyed. To function as designed, univents must be activated while classrooms are occupied.

Exhaust ventilation in classrooms is provided by ducted, grated ceiling or wall vents powered by rooftop motors (Pictures 3 and 4). These vents were operating during the assessment. It is important to note however, that the location of some exhaust vents can limit exhaust efficiency. In several areas exhaust vents are located above hallway doors (Picture 3). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Mechanical ventilation in the computer room, library and common areas such as the gymnasium and cafeteria is provided by air-handling units (AHUs) located in mechanical rooms and connected to ceiling or wall-mounted air diffusers via ductwork. Return air is drawn into wall or ceiling exhaust vents ducted back to the AHU. These systems were functioning during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment. The initial equipment balancing should have occurred after the installation of the new HVAC systems in 2002.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix A.

Temperature measurements ranged from 70° F to 74° F, which were within the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements in the building ranged from 33 to 38 percent, which were close to the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had water-damaged ceiling tiles, which can indicate leaks from the roof or plumbing system (Pictures 5 and 6/Table 1). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. The majority of stained ceiling tiles observed were located below elbows and joints for the sprinkler system that had slow dripping leaks (Pictures 7 and 8). Repeated water damage to porous building materials (e.g., wallboard, ceiling tiles, carpet) can result in microbial growth. Mold-colonized GW was observed near the base of the wall in the boiler room and on a bathroom ceiling tile in classroom 113.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of porous materials (i.e., gypsum wallboard (GW) and ceiling tiles) were taken in areas most likely impacted by water damage from the sprinkler release. A number of non-effected areas were measured for comparison (Table 2).

As discussed, moisture content was measured with a Delmhorst, BD-2000 Model, Moisture Detector. The Delmhorst probe is equipped with three lights that function as visual aids that indicate moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. Elevated moisture content was detected in GW in the corner of classroom 115, above the countertop (Picture 9). A small refrigerator and microwave oven were located in this corner. Although this equipment may be a *contributing* source of moisture, it is unlikely that they are the main cause. A bathroom is located directly on the opposite side of this wall. Plumbing fixtures for the bathroom would be a more likely source of moisture.

A green organic matter (mold/algae) was observed on exterior brick of the southwest corner of the building. The material was concentrated at the base of the exterior wall, beneath weep holes (Picture 10) and appeared to be the result of excessive moisture. In general, exterior wall systems should be designed to prevent moisture penetration to the building interior through the use of a drainage plane within the wall system to redirect water outdoors and allow for building components to dry. An exterior wall system should consist of an exterior curtain wall (Figure 2). Behind the curtain wall is an air space that allows for water to drain downward and for the exterior cladding system to dry. In order to allow for water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction.

Several classrooms contained a number of plants. In several classrooms, plants were found on top of univents. Plants, soil and drip pans can serve as sources of mold growth, and thus should be properly maintained. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants should also be located away from univents and ventilation sources to prevent aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide, PM2.5 and ultrafine particulates (UFPs) (particles measuring 0.02 μm to 1 μm in diameter).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. As indicated, the main reason for the assessment was to address concerns of carbon monoxide exposure and reoccurring odor complaints of exhaust emissions from the boiler plant and gas stove in the kitchen. On a number of occasions the EBFD had visited the school and had documented measurable levels of carbon monoxide, ranging from 7 to 12 ppm (EBFD, 2004a; EBFD, 2004b). In response, the East Brookfield School Department has had a number of energy consultants/vendors in the building to make adjustments/repairs to the boiler/venting system. On the day of the assessment, outdoor carbon monoxide concentrations were non-detect or ND. Carbon monoxide levels measured in the school were also ND (Table 1).

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 19 $\mu g/m^3$. PM2.5 levels measured indoors ranged from 4 to 12 $\mu g/m^3$ (Table 1), which was below background and well below the NAAQS of 65 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

The combustion of fossil fuels can also produce particulate matter of a small diameter (<0.1 μm) that can penetrate into the lungs and subsequently cause irritation. For this reason, a device that can measure particles of a diameter of 0.1 μm or less was also used to identify pollutant pathways from the boiler room into occupied areas. Inhaled particles can cause respiratory irritation. The instrument used by the BEHA to conduct air monitoring for UFPs counts the number of particles that are suspended per cubic centimeter (p/cc^3) of air. This type of air monitor is useful as a screening device, since it can be used to trace and identify the source of airborne pollutants by counting the actual number of airborne particles. The source of particle production can be identified by moving the ultrafine particle counter (UPC) through a building towards the highest measured concentration of airborne particles. Measured levels of p/cc^3 of air increase as the UPC is moved closer to the source of particle production.

Outdoor concentrations of UFPs were measured at 5.6 to 9 p/cc^3. The UFP level measured in the boiler room was measured at 3.1 p/cc^3 (Table 1), which was below background. However, spaces were observed around the boiler room door, where light from the room was evident (Picture 11). These spaces can serve as a means of egress for odors, fumes, dusts and vapors from the boiler room into adjacent areas. It also appeared that the actuator bar to the intake louvers to the boiler make-up air vent was disconnected and a stick was temporarily lodged in its place to hold them open (Picture 12).

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND) (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions that can affect indoor air quality were observed during the assessment. BEHA staff inspected AHU filters in the mechanical room and found the filters coated with dirt/dust and accumulated material (Pictures 13 and 14). A debris-saturated filter can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system. In addition, a number of exhaust and return vents had accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles leading to eye, and respiratory irritation.

Finally of note was the amount of materials stored in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Dust can be irritating to eyes, nose and respiratory tract.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue working with energy consultants/vendors to make adjustments/repairs to the boiler/venting system and in particular the make-up air vent shown in Picture 12.
2. Install a door sweep and/or weather-stripping around boiler room door to prevent the potential egress of odors and particulates into adjacent areas.
3. Contact a fire prevention firm or plumbing contractor specializing in sprinkler systems to isolate and repair water leaks building-wide. Repair/replace any water-damaged ceiling tiles, plaster and/or other damaged building materials. Examine above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Building occupants should report any roof leaks or other signs of water penetration to school maintenance staff for prompt remediation.
4. Remove a small section of GW in classroom 115 to give maintenance personnel the opportunity to observe conditions within the wall cavity and to determine if a chronic source of moisture exists in the wall cavity.
5. Remove and replace all mold contaminated materials in a manner consistent with "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html. This measure will remove actively growing mold colonies that may be present. This work should be conducted at a time when occupants are not present in the area. Contain the area where contaminated materials are removed to prevent the spread of dust and mold spores. It is

recommended that ventilation components be deactivated and sealed with plastic sheeting and duct tape; and that local exhaust ventilation be employed to place the mechanical room under negative pressure to prevent mold spores and associated materials from migrating into adjacent areas.

6. Ensure the remediated area is thoroughly cleaned and disinfected with an appropriate antimicrobial once work is completed. Dust and particulates resulting from renovation efforts should be vacuumed with a high efficiency particulate arrestance (HEPA) filtered vacuum cleaner.
7. Remove and replace mold-contaminated GW in boiler room.
8. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001) for further information on mold and/or mold clean up. Copies of this document are available from the US EPA at: http://www.epa.gov/iaq/molds/mold_remediation.html.
9. Contact a masonry/architectural firm or building envelope specialists to examine weep holes on the south west corner of the building for proper drainage.
10. Operate both supply and exhaust ventilation continuously during periods of school occupancy, independent of classroom thermostat control to maximize air exchange.
11. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Close classroom doors to improve exhaust ventilation.
12. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
13. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to

minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

14. Change filters for AHUs and unit ventilators as per manufacturer's instructions or more frequently if needed.

15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Clean exhaust/return vents periodically to prevent excessive dust build-up.

17. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

18. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Figure 2

The Function of the Drainage Plane and Weep Holes to Drain Water from the Wall System, Prevent Moisture Penetration into the Interior

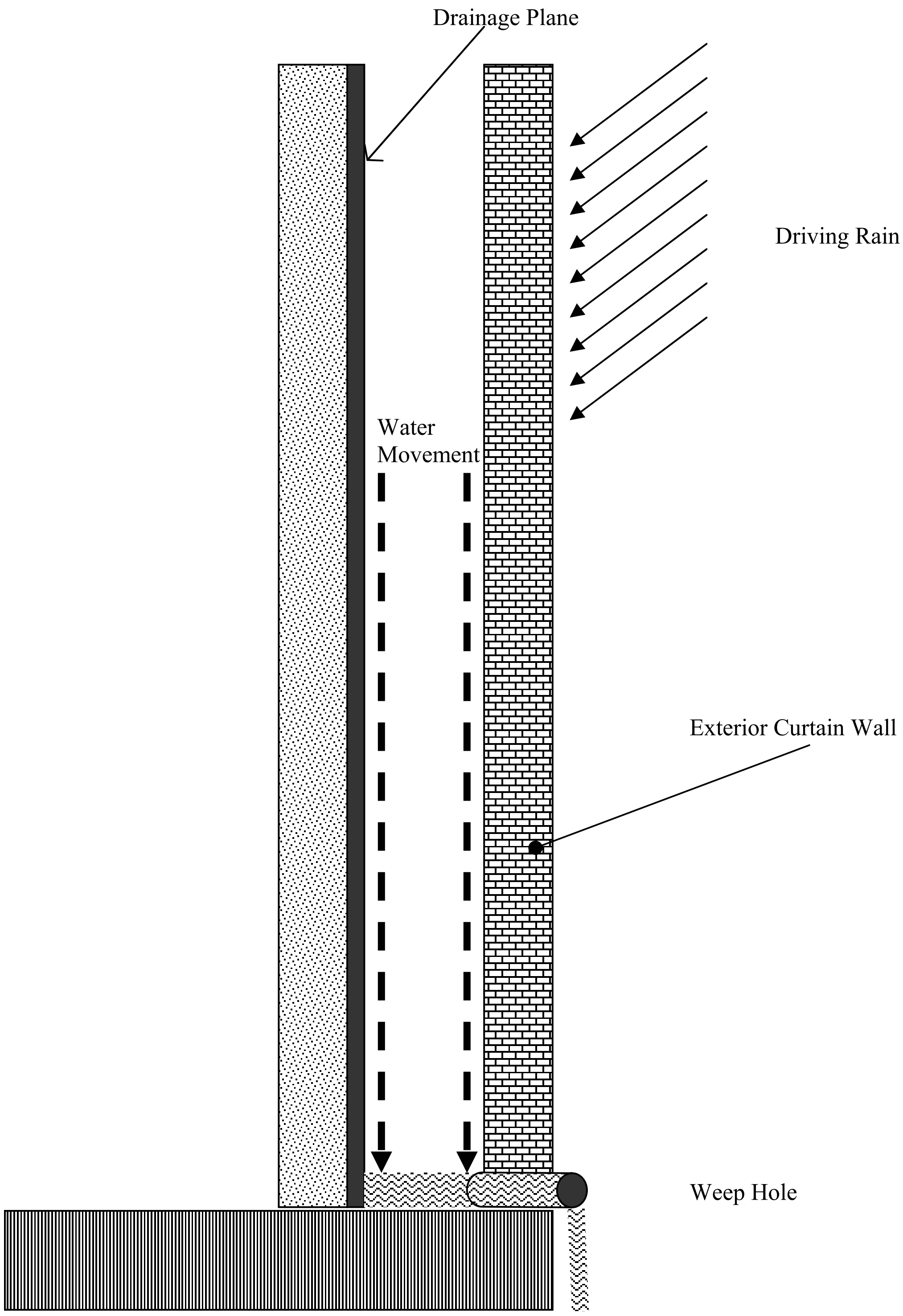


Figure 3
Weep Hole Blocked with Wick and Water Accumulation in the Drainage Plane

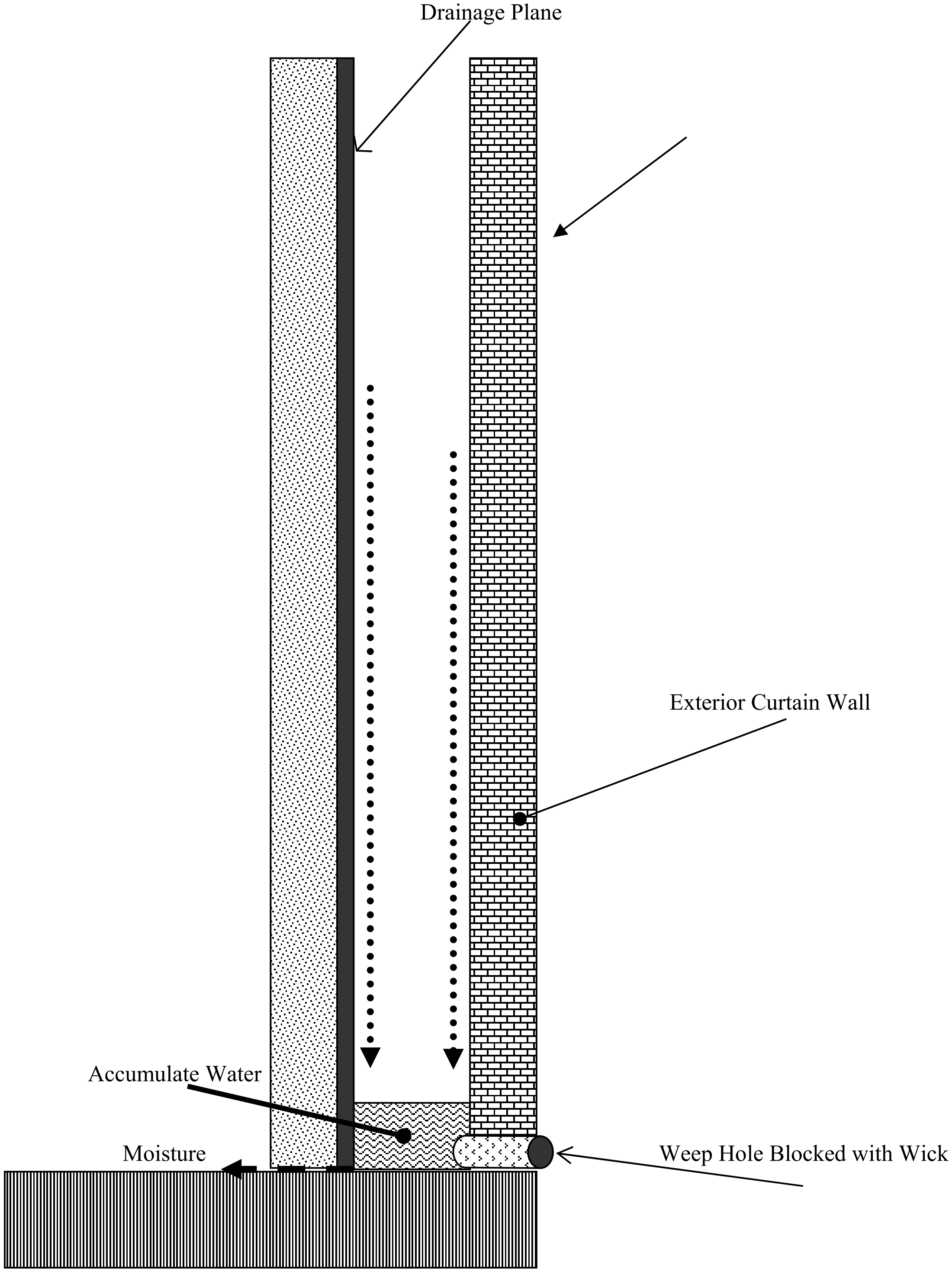


Figure 5
Draw of Moisture From Wall System Into Univent Fresh Air Intake Vent

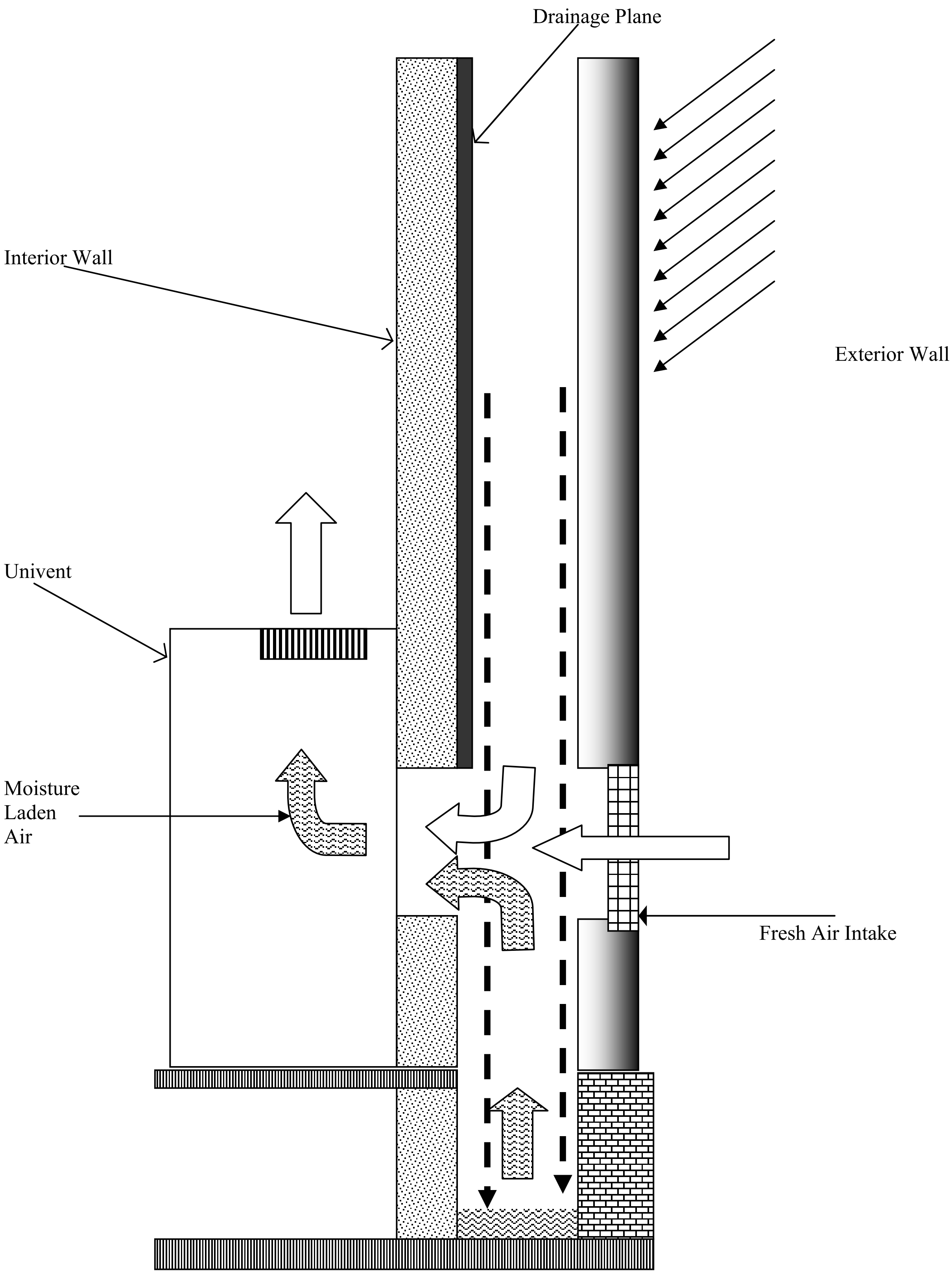
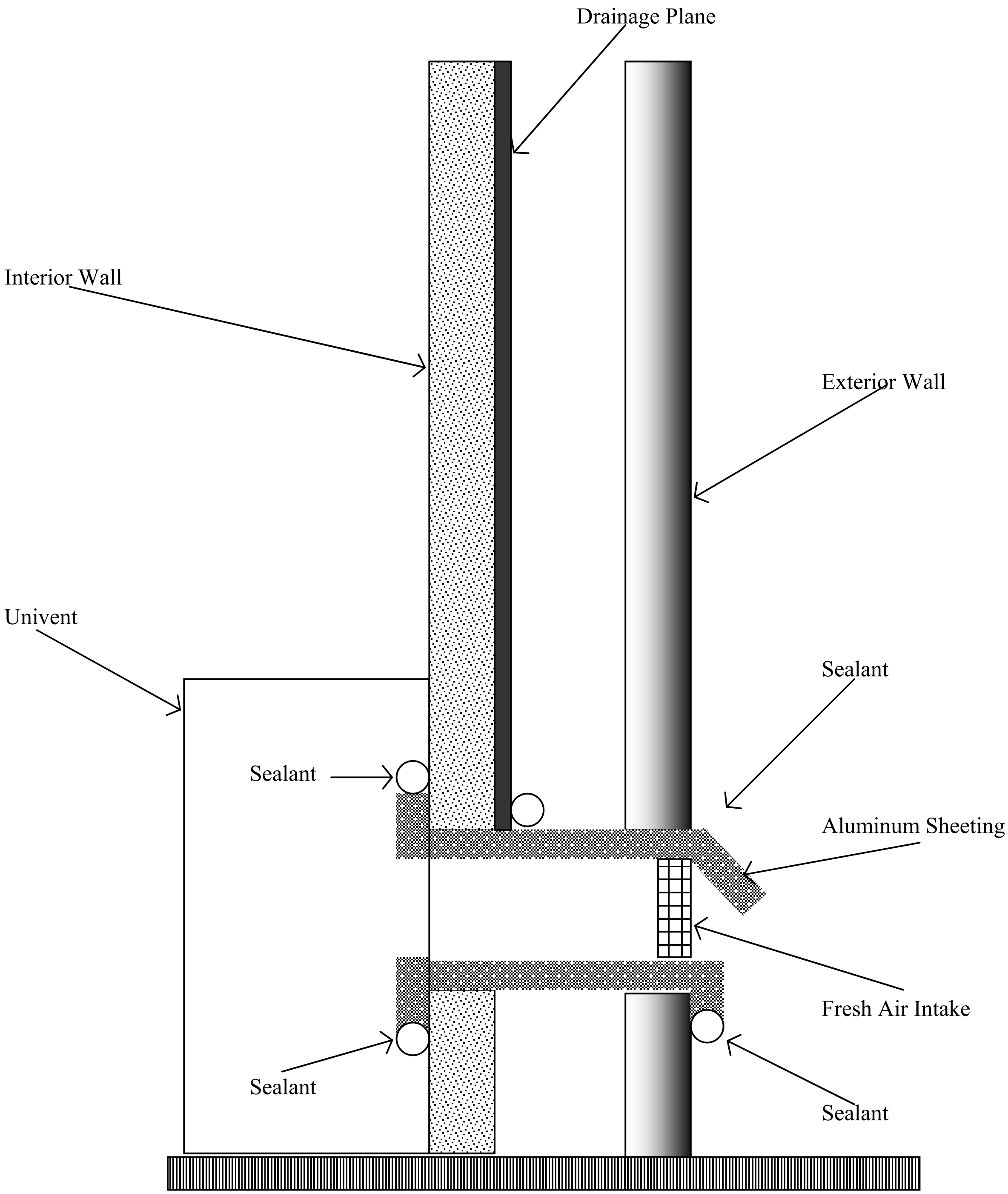


Figure 6
Sealing of Univent Fresh Air Intake Vent from Exterior Wall Drainage Plane



Picture 1

Classroom Univent

Picture 2

Univent Fresh Air Intake

Picture 3

Ceiling-Mounted Exhaust Vent, Note Proximity to Hallway Door

Picture 4

Rooftop Exhaust Motors

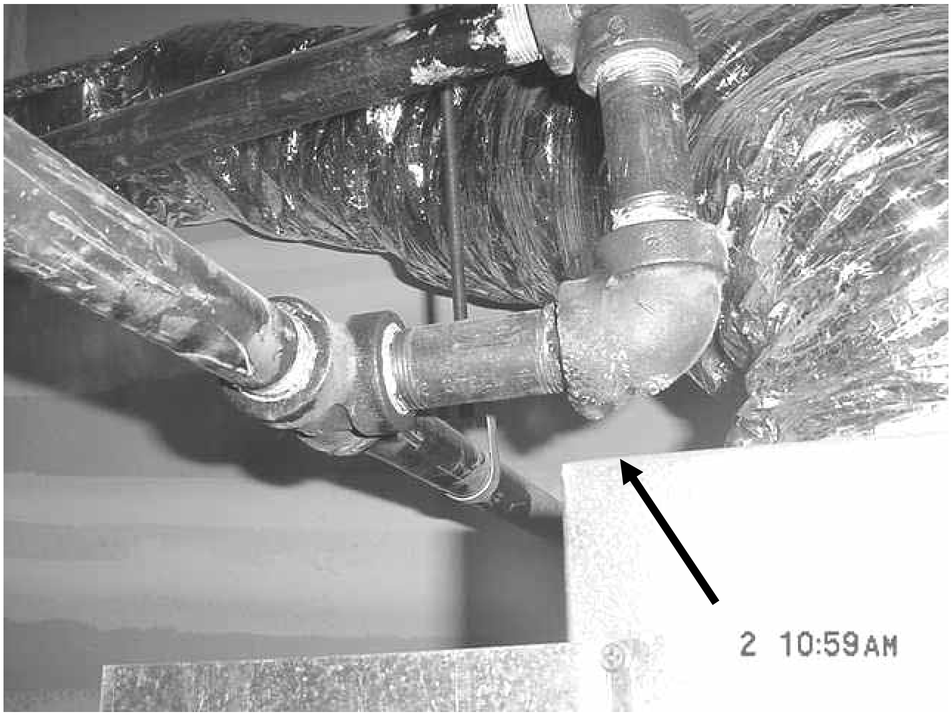
Picture 5

Water Damaged Ceiling Tile in Kitchen Area near Sprinkler Release

Picture 6

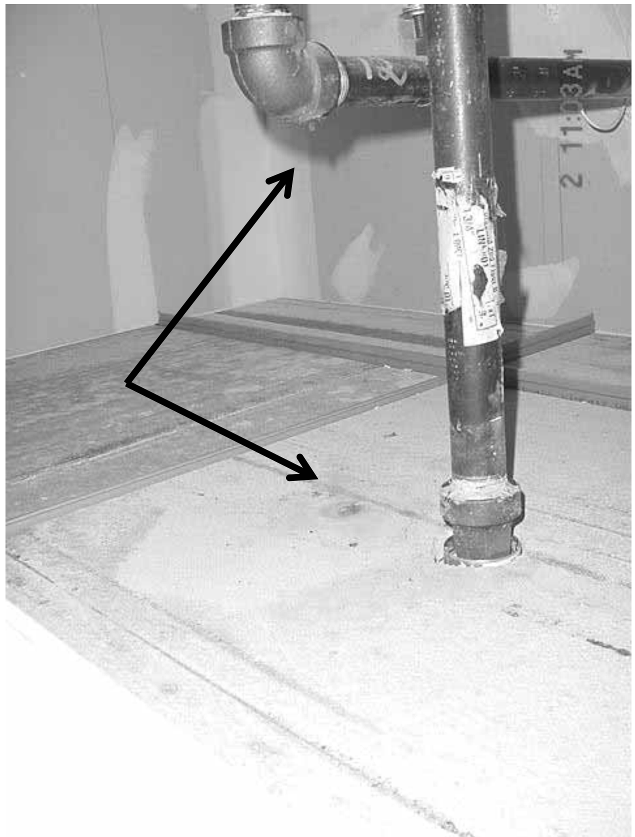
Water Damaged Ceiling Tile, Dark Stain Indicates Possible Mold Growth

Picture 7



Slow-Dripping Sprinkler Pipe Joint above Ceiling Tile System in Kitchen Area near Restroom

Picture 8

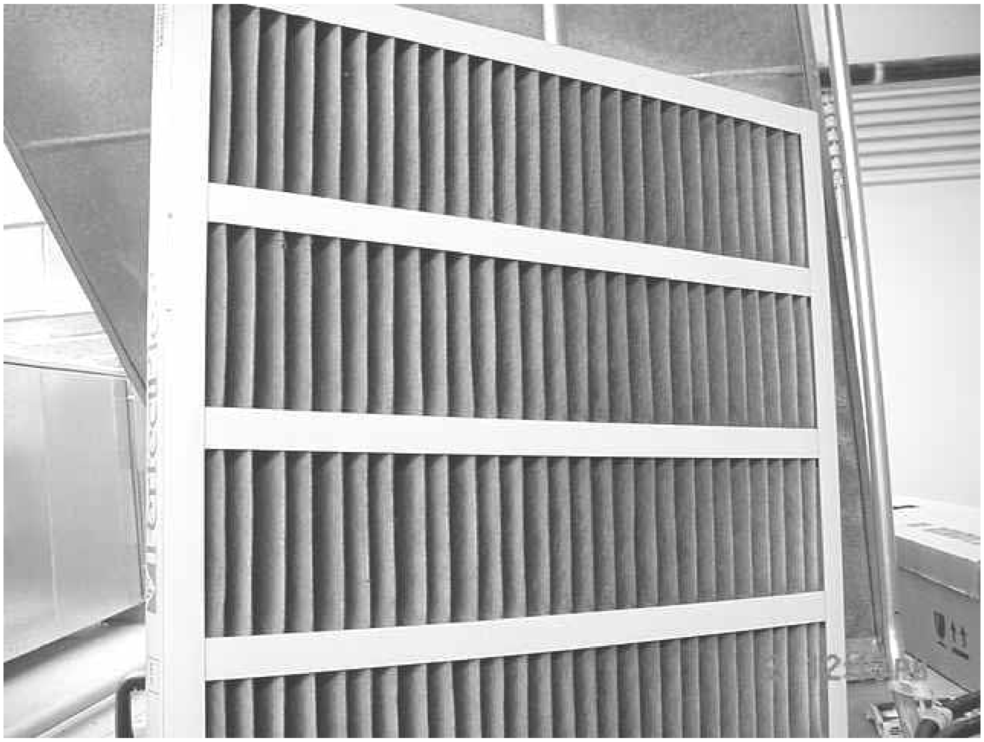


Dripping Sprinkler Joint above Water Damaged Ceiling Tile

Picture 9

Corner of Classroom 115 Where Elevated Moisture Readings were Taken

Picture 10



AHU Filter Occluded with Dust and Debris in Mechanical Room

Picture 11

Filter in AHU dated June 3, 2003

Picture 12

Space beneath Boiler Room Door

Picture 13

Disconnected Actuator Control to Make up Air Vent to Boiler Room,
Note Piece of Wood to Hold Louvers Open

East Brookfield Elementary School | **Indoor Air Results**

410 East Main Street, East Brookfield, MA | **November 2, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (Outdoors)	59	40	366	ND	ND	19	-	-	-	-	Atmospheric conditions: Partly cloudy, N winds 5-10 mph, ultrafine particulate reading 5.6-7.9 p/cc3**
Kitchen Bathroom Area							9				GW above CT-low moisture, WD CT's, dripping pipe/elbow to sprinkler system near men's room
112											Low moisture GW
113	74	34	550	ND	ND	8	17	Y	Y	Y Univent	Low moisture GW, WD tile in bathroom possible mold growth, DEM, plants
114											Low moisture GW, no visible mold growth/odors
115	73	33	573	ND	ND	8	6-	Y	Y Univent	Y Ceiling	Elevated moisture measurements in GW-corner countertop near microwave, no visible mold growth/odors, low moisture in walls

ppm = parts per million
µg/m3 = micrograms per cubic meter
**1000p/cc^3 particles per cubic centimeter
AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
UV = univent
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
											adjacent to this area
108	72	36	761	ND	ND	12	15	Y	Y Univent	Y Ceiling	DO, DEM, plants, UV obstructed with clutter
213	70	33	498	ND	ND	7	0	Y	Y Univent	Y Ceiling	Decomposition experiment-mold/odors, DEM
206	71	34	508	ND	ND	8	2	Y	Y Univent	Y Ceiling	DEM, dusty exhaust vent
205	74	35	572	ND	ND	4	2	Y	Y Univent	Y Ceiling	DEM
Library	73	33	474	ND	ND	8	17	Y	Y Univent	Y Ceiling	plants
Computer Room	73	33	528	ND	ND	7	17	Y	Y Ceiling	Y Ceiling	DEM

ppm = parts per million
µg/m3 = micrograms per cubic meter
**1000p/cc^3 particles per cubic centimeter
AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
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CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
UV = univent
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

East Brookfield Elementary School

410 East Main Street, East Brookfield, MA

Table 1

Indoor Air Results

November 2, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Boiler Room	71	38	575	ND	ND	12	0	N	Y	Y	Visible mold growth along baseboard, actuator dissconne3cted from a make-up air intake-stick stuck in vent to hold louvers open, ultrafine particulate reading 3.1 p/cc^3
104	71	34	567	ND	ND	7	11	Y	Y Univent	Y Ceiling	Exhaust n ear hallway door, DEM, plants, UV obstructed by clutter

ppm = parts per million
µg/m3 = micrograms per cubic meter
**1000p/cc^3 particles per cubic centimeter
AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
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